CLAIMS

1. A method for combusting a fuel in a cyclone combustor having a burner in communication with a barrel having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising the steps of:

feeding a stream of the fuel into the barrel of the cyclone combustor at the burner end of the cyclone combustor;

feeding at least one stream of a first oxidant having a first oxygen concentration of about 21 vol.% into the barrel of the cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

feeding at least one stream of a second oxidant having a second oxygen concentration greater than the first oxygen concentration into the barrel of the cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the cyclone combustor combines with at least a portion of the second oxidant in the barrel of the cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the cyclone combustor continues having the first oxygen concentration; and

combusting at least a portion of the fuel in the barrel of the cyclone combustor with at least a portion of the combined oxidant in the barrel of the cyclone combustor.

2. A method as in claim 1, wherein the fuel is coal.

3. A method as in claim 1, wherein the at least one stream of the first oxidant further comprises a primary oxidant stream having an oxygen concentration of about 21 vol.%, comprising the further step of:

mixing at least a portion of the stream of the fuel with at least a portion of the primary oxidant stream to form a mixed stream,

wherein at least a portion of the at least one stream of the second oxidant is fed into the barrel of the cyclone combustor at a first location adjacent the mixed stream.

4. A method as in claim 1, wherein the at least one stream of the first oxidant further comprises a primary oxidant stream having an oxygen concentration of about 21 vol.%, and wherein at least a portion of the at least one stream of the second oxidant fed into the barrel of the cyclone combustor is combined with at least a portion of the primary oxidant stream.

5. A method as in claim 1, wherein at least a portion of the at least one stream of the second oxidant fed into the barrel of the cyclone combustor flows substantially along the longitudinal axis of the barrel of the cyclone combustor.

6. A method as in claim 5, wherein the at least a portion of the at least one stream of the second oxidant flowing substantially along the longitudinal axis of the barrel of the cyclone combustor has a swirling motion.

7. A method as in claim 1, wherein at least a portion of the at least one stream of the second oxidant is fed into the barrel of the cyclone combustor at a second location adjacent the burner end of the cyclone combustor.

8. A method as in claim 1, wherein at least a portion of the at least one stream of the second oxidant is fed into the barrel of the cyclone combustor at an intermediate location between the burner end and the throat end of the cyclone combustor.

9. A method as in claim 1, wherein at least a portion of the at least one stream of the second oxidant is fed into the barrel of the cyclone combustor at a third location adjacent the throat end of the cyclone combustor.

10. A method as in claim 1, wherein the combined oxygen concentration is less than about 31 vol.%.

11. A method for combusting a slagging coal with at least a first oxidant having a first oxygen concentration of about 21 vol.% and a second oxidant having a second oxygen concentration greater than the first oxygen concentration in a slagging cyclone combustor in communication with a furnace while minimizing an amount of nitrogen oxide emissions in a flue gas generated during combustion of the slagging coal, said slagging coal not being amenable to use in the slagging cyclone combustor operated with a flow of air as an only oxidant, the slagging cyclone combustor having a burner in communication with a barrel having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising the steps of:

feeding a stream of the slagging coal into the barrel of the slagging cyclone combustor at the burner end of the slagging cyclone combustor;

feeding at least one stream of the first oxidant into the barrel of the slagging cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

feeding at least one stream of the second oxidant into the barrel of the slagging cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the slagging cyclone combustor combines with at least a portion of the second oxidant in the barrel of the slagging cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the slagging cyclone combustor continues having the first oxygen concentration;

combusting at least a portion of the slagging coal in the barrel of the slagging cyclone combustor with at least a portion of the first oxidant and at least a portion of the combined oxidant in the barrel of the slagging cyclone combustor, thereby generating the flue gas and a stable and continuous flow of a molten slag in the barrel of the slagging cyclone combustor;

draining at least a portion of the stable and continuous flow of the molten slag from the barrel of the slagging cyclone combustor; and

transferring at least a portion of the flue gas from the barrel of the slagging cyclone combustor to the furnace.

12. A method for extending a range of amenable fuel types and operating parameters of a slagging cyclone combustor having a burner in communication with a barrel

having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising the steps of:

feeding a stream of the fuel into the barrel of the slagging cyclone combustor at the burner end of the slagging cyclone combustor;

feeding at least one stream of a first oxidant having a first oxygen concentration of about 21 vol.% into the barrel of the slagging cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

feeding at least one stream of a second oxidant having a second oxygen concentration greater than the first oxygen concentration into the barrel of the slagging cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the slagging cyclone combustor combines with at least a portion of the second oxidant in the barrel of the slagging cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the slagging cyclone combustor continues having the first oxygen concentration; and

combusting at least a portion of the fuel in the barrel of the slagging cyclone combustor with at least a portion of the combined oxidant in the barrel of the slagging cyclone combustor, thereby generating a plurality of products of combustion and a stable and continuous flow of a molten slag in the barrel of the slagging cyclone combustor.

13. A method as in claim 12, comprising the further step of:

draining at least a portion of the stable and continuous flow of the molten slag from the barrel of the slagging cyclone combustor.

14. A method as in claim 12, wherein the fuel is coal.

15. A method for reducing nitrogen oxide emissions from a flue gas generated during combustion of a fuel in a cyclone combustor having a burner in communication with a barrel having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising the steps of:

feeding a stream of the fuel into the barrel of the cyclone combustor at the burner end of the cyclone combustor;

feeding at least one stream of a first oxidant having a first oxygen concentration of about 21 vol.% into the barrel of the cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

feeding at least one stream of a second oxidant having a second oxygen concentration greater than the first oxygen concentration into the barrel of the cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the cyclone combustor combines with at least a portion of the second oxidant in the barrel of the cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the cyclone combustor continues having the first oxygen concentration; and

combusting at least a portion of the fuel in the barrel of the cyclone combustor with at least a portion of the combined oxidant in the barrel of the cyclone combustor, thereby generating the flue gas containing a reduced amount of nitrogen oxide in the barrel of the cyclone combustor, said reduced amount of nitrogen oxide being less than a higher amount of nitrogen oxide that would be generated by the cyclone combustor operated with a flow of air as an only oxidant.

16. A method as in claim 15, wherein the throat end of the barrel of the cyclone combustor is in fluid communication with a furnace, comprising the further steps of:

transferring at least a portion of the flue gas from the barrel of the cyclone combustor to the furnace;

feeding a stream of a secondary fuel into the furnace; and

combusting at least a portion of the secondary fuel in the furnace.

17. A method as in claim 15, wherein the first flowrate and the second flowrate result in a stoichiometric ratio less than about 1.0 in the barrel of the cyclone combustor.

18. A method for operating a steam-generating boiler or furnace in communication with a cyclone combustor having a burner in communication with a barrel having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising the steps of:

feeding a stream of the fuel into the barrel of the cyclone combustor at the burner end of the cyclone combustor;

feeding at least one stream of a first oxidant having a first oxygen

concentration of about 21 vol.% into the barrel of the cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

feeding at least one stream of a second oxidant having a second oxygen concentration greater than the first oxygen concentration into the barrel of the cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the cyclone combustor combines with at least a portion of the second oxidant in the barrel of the cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the cyclone combustor continues having the first oxygen concentration;

combusting at least a portion of the fuel in the barrel of the cyclone combustor with at least a portion of the combined oxidant in the barrel of the cyclone combustor, thereby generating an amount of thermal energy in the barrel of the cyclone combustor; and

transferring at least a portion of the amount of thermal energy from the barrel of the cyclone combustor to the steam-generating boiler or furnace.

19. A system for combusting a fuel in a cyclone combustor having a burner in communication with a barrel having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising:

means for feeding a stream of the fuel into the barrel of the cyclone combustor at the burner end of the cyclone combustor;

means for feeding at least one stream of a first oxidant having a first oxygen concentration of about 21 vol.% into the barrel of the cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

means for feeding at least one stream of a second oxidant having a second oxygen concentration greater than the first oxygen concentration into the barrel of the cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the cyclone combustor combines with at least a portion of the second oxidant in the barrel of the cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the cyclone combustor continues having the first oxygen concentration; and

means for combusting at least a portion of the fuel in the barrel of the cyclone combustor with at least a portion of the combined oxidant in the barrel of the cyclone combustor.

20. A system as in claim 19, wherein the fuel is coal.

21. A system as in claim 19, wherein the at least one stream of the first oxidant further comprises a primary oxidant stream having an oxygen concentration of about 21 vol.%, further comprising:

means for mixing at least a portion of the stream of the fuel with at least a portion of the primary oxidant stream to form a mixed stream,

wherein at least a portion of the at least one stream of the second oxidant is fed into the barrel of the cyclone combustor at a first location adjacent the mixed stream.

22. A system as in claim 19, wherein the at least one stream of the first oxidant further comprises a primary oxidant stream having an oxygen concentration of about 21 vol.%, and wherein at least a portion of the at least one stream of the second oxidant fed into the barrel of the cyclone combustor is combined with at least a portion of the primary oxidant stream.

23. A system as in claim 19, wherein at least a portion of the at least one stream of the second oxidant fed into the barrel of the cyclone combustor flows substantially along the longitudinal axis of the barrel of the cyclone combustor.

24. A system as in claim 23, wherein the at least a portion of the at least one stream of the second oxidant flowing substantially along the longitudinal axis of the barrel of the cyclone combustor has a swirling motion.

25. A system as in claim 19, wherein at least a portion of the at least one stream of the second oxidant is fed into the barrel of the cyclone combustor at a second location adjacent the burner end of the cyclone combustor.

26. A system as in claim 19, wherein at least a portion of the at least one stream of the second oxidant is fed into the barrel of the cyclone combustor at an intermediate location between the burner end and the throat end of the cyclone combustor.

27. A system as in claim 19, wherein at least a portion of the at least one stream of the second oxidant is fed into the barrel of the cyclone combustor at a third location adjacent the throat end of the cyclone combustor.

28. A system as in claim 19, wherein the combined oxygen concentration is less than about 31 vol.%.

29. A system for combusting a slagging coal with at least a first oxidant having a first oxygen concentration of about 21 vol.% and a second oxidant having a second oxygen concentration greater than the first oxygen concentration in a slagging cyclone combustor in communication with a furnace while minimizing an amount of nitrogen oxide emissions in a flue gas generated during combustion of the slagging coal, said slagging coal not being amenable to use in the slagging cyclone combustor operated with a flow of air as an only oxidant, the slagging cyclone combustor having a burner in communication with a barrel having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising:

means for feeding a stream of the slagging coal into the barrel of the slagging cyclone combustor at the burner end of the slagging cyclone combustor;

means for feeding at least one stream of the first oxidant into the barrel of the slagging cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

means for feeding at least one stream of the second oxidant into the barrel of the slagging cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the

cyclone combustor combines with at least a portion of the second oxidant in the barrel of the slagging cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the slagging cyclone combustor continues having the first oxygen concentration;

means for combusting at least a portion of the slagging coal in the barrel of the slagging cyclone combustor with at least a portion of the first oxidant and at least a portion of the combined oxidant in the barrel of the slagging cyclone combustor, thereby generating the flue gas and a stable and continuous flow of a molten slag in the barrel of the slagging cyclone combustor;

means for draining at least a portion of the stable and continuous flow of the molten slag from the barrel of the slagging cyclone combustor; and

means for transferring at least a portion of the flue gas from the barrel of the slagging cyclone combustor to the furnace.

30. A system for extending a range of amenable fuel types and operating parameters of a slagging cyclone combustor having a burner in communication with a barrel having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising:

means for feeding a stream of the fuel into the barrel of the slagging cyclone combustor at the burner end of the slagging cyclone combustor;

means for feeding at least one stream of a first oxidant having a first

oxygen concentration of about 21 vol.% into the barrel of the slagging cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

means for feeding at least one stream of a second oxidant having a second oxygen concentration greater than the first oxygen concentration into the barrel of the slagging cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the slagging cyclone combustor combines with at least a portion of the second oxidant in the barrel of the slagging cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the slagging cyclone combustor continues having the first oxygen concentration; and

means for combusting at least a portion of the fuel in the barrel of the slagging cyclone combustor with at least a portion of the combined oxidant in the barrel of the slagging cyclone combustor, thereby generating a plurality of products of combustion and a stable and continuous flow of a molten slag in the barrel of the slagging cyclone combustor.

31. A system as in claim 30, further comprising:

means for draining at least a portion of the stable and continuous flow of the molten slag from the barrel of the slagging cyclone combustor.

32. A system as in claim 30, wherein the fuel is coal.

33. A system for reducing nitrogen oxide emissions from a flue gas generated during combustion of a fuel in a cyclone combustor having a burner in communication with a barrel having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising:

means for feeding a stream of the fuel into the barrel of the cyclone combustor at the burner end of the cyclone combustor;

means for feeding at least one stream of a first oxidant having a first oxygen concentration of about 21 vol.% into the barrel of the cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

means for feeding at least one stream of a second oxidant having a second oxygen concentration greater than the first oxygen concentration into the barrel of the cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the cyclone combustor combines with at least a portion of the second oxidant in the barrel of the cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the cyclone combustor continues having the first oxygen concentration; and

means for combusting at least a portion of the fuel in the barrel of the cyclone combustor with at least a portion of the combined oxidant in the barrel of the cyclone combustor, thereby generating the flue gas containing a reduced amount of nitrogen oxide in the barrel of the cyclone combustor, said reduced amount of nitrogen oxide being less than a higher amount of

nitrogen oxide that would be generated by the cyclone combustor operated with a flow of air as an only oxidant.

34. A system as in claim 33, wherein the throat end of the barrel of the cyclone combustor is in fluid communication with a furnace, further comprising:

means for transferring at least a portion of the flue gas from the barrel of the cyclone combustor to the furnace;

means for feeding a stream of a secondary fuel into the furnace; and

means for combusting at least a portion of the secondary fuel in the furnace.

35. A system as in claim 33, wherein the first flowrate and the second flowrate result in a stoichiometric ratio less than about 1.0 in the barrel of the cyclone combustor.

36. A system for operating a steam-generating boiler or furnace in communication with a cyclone combustor having a burner in communication with a barrel having a longitudinal axis, a burner end adjacent the burner, and a throat end opposite the burner end, comprising:

means for feeding a stream of the fuel into the barrel of the cyclone combustor at the burner end of the cyclone combustor;

means for feeding at least one stream of a first oxidant having a first oxygen concentration of about 21 vol.% into the barrel of the cyclone combustor at a first flowrate, the at least one stream of the first oxidant comprising at least one predominant stream of the first oxidant;

means for feeding at least one stream of a second oxidant having a

second oxygen concentration greater than the first oxygen concentration into the barrel of the cyclone combustor at a second flowrate and in a selective manner, whereby a portion of the first oxidant in the barrel of the cyclone combustor combines with at least a portion of the second oxidant in the barrel of the cyclone combustor, thereby forming a combined oxidant having a combined oxygen concentration greater than the first oxygen concentration and less than the second oxygen concentration, and at least a portion of the first oxidant from the at least one predominant stream of the first oxidant in the barrel of the cyclone combustor continues having the first oxygen concentration;

means for combusting at least a portion of the fuel in the barrel of the cyclone combustor with at least a portion of the combined oxidant in the barrel of the cyclone combustor, thereby generating an amount of thermal energy in the barrel of the cyclone combustor; and

means for transferring at least a portion of the amount of thermal energy from the barrel of the cyclone combustor to the steam-generating boiler or furnace.